ENDOPARASITIC POLYCHAETOUS ANNELIDS OF THE FAMILY ARABELLIDAE WITH DESCRIPTIONS OF NEW SPECIES[1]

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Among the polychaetes, which for the most part are free-living, crawling, burrowing, and tube-dwelling, commensalism is rather common but internal parasitism is rare indeed. Among the relatively few cases that have been reported are some lumbrinerid-like polychaetes belonging to the superfamily Eunicea, which includes the families Eunicidae, Onuphidae, Lumbrineridae, Arabellidae, Lysaretidae, and Dorvilleidae (sometimes considered as subfamilies belonging to the family Eunicidae). Some of the parasitic euniceans invade other members of the same superfamily and may attain an enormous size in proportion to the host. All of the known lumbrinerid-like parasites belong to, or show affinities to, the family Arabellidae as defined by Hartman (1944).

In connection with a study of polychaete material from various sources, including that in the United States National Museum, some arabellids were found living as endoparasites in other polychaetes of the related family Onuphidae. Two new species are described herein, the types of which are deposited in the United States National Museum. Some small specimens of a third species, living parasitically in the onuphid, *Diopatra*, are thought to be the young stages of the arabellid, *Notocirrus spiniferus* (Moore). Since this interesting type of parasitism is not widely known and has not received the attention it no doubt deserves, the relatively few known cases of lumbrinerid-like species living in other polychaetes and echiuroids are reviewed and the chief characteristics of the Eunicea and Arabellidae to which the parasites belong are summarized.

Superfamily EUNICEA

All the members of the Eunicea are equipped with a complex series of strong, dark, chitinous or horny jaws. The pharynx is capable of protrusion and is provided with a pair of ventral plates, called mandibles, and a more dorsal bilaterally arranged series of plates, called maxillae. The prostomium is distinct, with or without eyes or appendages. Typically the first two segments are apodous. The parapodia are essentially uniramous, the upper lobe or notopodium represented at most by a few embedded notoacicula and a rudimentary papilla-like lobe. The members of the Eunicea vary from those of minute size with a moderate number of segments to some very large ones with very numerous segments, some of which are among the largest of the polychaetes. They are essentially free-living, predaceous, and carnivorous. They secrete abundant mucus, which may aid in burrowing or forming temporary or more or less permanent tubes.

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Family ARABELLIDAE Hartman

The arabellids show a superficial resemblance to the members of the Lumbrineridae, differing from them in setal and pharyngeal characters. They have the body elongate, cylindrical, of nearly uniform width, and tapering slightly anteriorly and posteriorly. The prostomium is reduced to a simple, conical or flattened spatulate lobe, without appendages, with or without eyespots on the posterior margin. The first two segments are distinct, apodous, and without appendages. The parapodia are essentially uniramous; the notopodia sometimes represented by a minute papillar lobe (sometimes referred to as a reduced dorsal cirrus) with embedded notoacicula; the neuropodia are unequally bilobed, with shorter rounded and longer digitiform postsetal lobes. The neurosetae are simple (not compound), limbate, and taper to fine tips; in addition they sometimes have projecting thick

TABLE I

Parasite	Host and Distribution	References
Notocirrus sp. (young)	Eunicidae: *Marphysa sanguinea* (Montagu). Mediterranean	Koch, 1847. Ehlers, 1868, p. 364. See below
Notocirrus ?spiniferus (Moore) (young)	Onuphidae: *Diopatra cuprea* (Bosc). Woods Hole region, Massachusetts	Allen, 1952. See below
Haematocleptes terebellidis Wirén	Terebellidae: *Terebellides stroemii* Sars. Off Sweden, 130 meters	Wirén, 1886
Labrorostratus parasiticus Saint-Joseph	Syllidae: *Odontosyllis ctenostoma* Claparède, *Syllis prolifera* Krohn, *Eusyllis monilicornis* Malmgren, *Pionosyllis lamelligera* Saint-Joseph, *Grubea clavata* (Claparède)	Saint-Joseph, 1888. Caullery and Mesnil, 1916. Fauvel, 1923, p. 440
Oligognathus bonelliae Spengel	Echiuroidea: *Bonellia viridis* Rolando. Mediterranean	Spengel, 1882. Fauvel, 1923, p. 442
Oligognathus parasiticus Cerruti	Spionidae: *Spio mecznikowianus* Claparède. Mediterranean	Cerruti, 1909. Fauvel, 1923, p. 442
Drilonereis parasiticus (Caullery)	Terebellidae: Genus and species? Near Timor, Dutch East Indies, 73 meters	Caullery, 1914. See below
Drilonereis forcipes (Hartman)	Eunicidae: *Eunice* sp., possibly *E. antennata* Savigny. San Benito Island, Lower California, 66–81 fathoms	Hartman, 1944. See below
Drilonereis benedicti n. sp.	Onuphidae: *Onuphis magna* (Webster). Tampa Bay, Florida, 12 fms.	See below
Drilonereis caulleryi n. sp.	Onuphidae: *Onuphis* (*Nothria*) *conchylega* Sars. Off Massachusetts to off Virginia, 101–317 fms.	See below

acicular setae or acicula (without hooded hooks as in the Lumbrineridae). The parapodia have no dorsal or ventral cirri or branchiae. The eversible proboscis is equipped with strong, chitinous, black jaw pieces: usually with a pair of ventral, flat plates, the mandibles; with 4 or 5 pairs (may be fewer in parasitic forms) of more dorsal maxillae arranged in parallel rows, with a pair of long filiform carriers to which a shorter median unpaired piece is attached on the ventral side. The arabellids are essentially a burrowing, predaceous, carnivorous group. They burrow readily but rather slowly in sand or mud. They secrete a good deal of mucus, which probably serves to lubricate the burrow.

Some of the arabellids are parasitic in other polychaetes (eunicids, onuphids, syllids, terebellids) and in echiuroids (*Bonellia*), living inside the body cavity or vascular body wall or even in the vascular system of the host, at least during their

early developmental stages. The eight previously reported parasitic arabellids, along with the two species described herein, are summarized in Table I and in the illustrated Key to the genera and species.

Illustrated Key to the Genera and Species of Parasitic Arabellidae

[Figures are copied from the original descriptions. a, anterior end; b, parapodium; c, setae; d, mandibles; e, maxillae and maxillary carriers; f, maxillae]

A¹. Numerous specimens in single host.

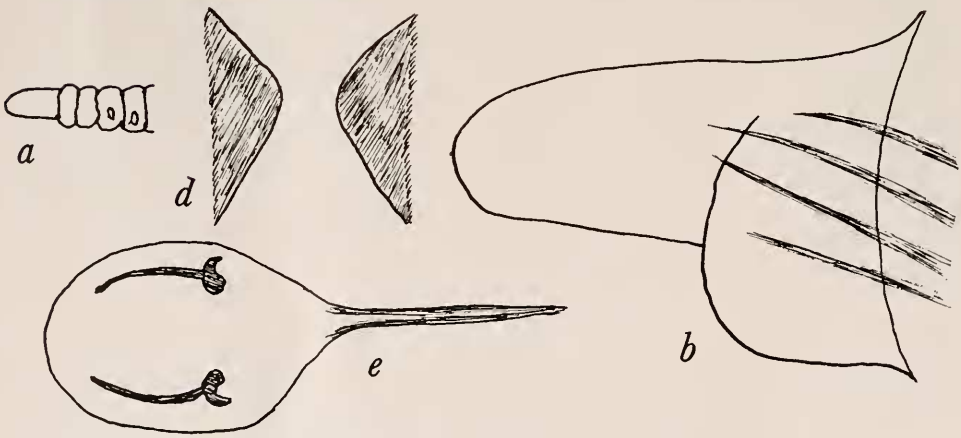
B¹. Parasitic in body cavity of *Marphysa sanguinea* . . . *Notocirrus* sp. (young). (See below under *N. spiniferus*.)

B². Parasitic in body cavity and vascular body wall of *Diopatra cuprea* *Notocirrus ?spiniferus* (young). (See Figs. 4, g and 5.)

A². One parasite per host.

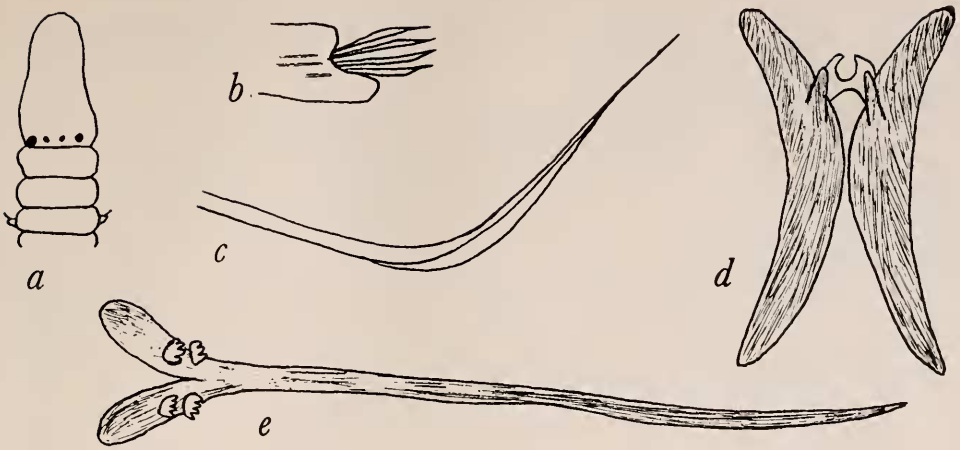
C¹. One to three pairs of rudimentary maxillae, with single elongate rodlike maxillary carrier. Mandibles present.

D¹. Maxillae a single pair of curved rods, each curved tooth at base. Setae and acicula not projecting from lobe. Mandibles paired, triangular. Prostomium without eyes. (Up to 25 mm. long, about 200 segments. Colorless.) Parasitic in perintestinal blood sinus of *Terebellides stroemii*. . . . Genus *Haematocleptes* Wirén *H. terebellidis* Wirén



D². Two or three pairs of maxillae. Setae projecting from parapodial lobe.

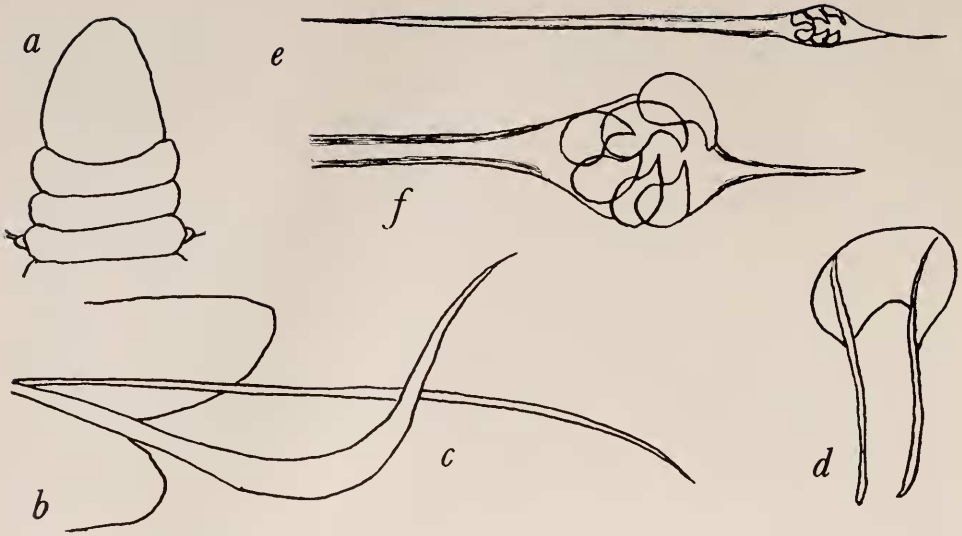
E¹. Maxillae two pairs of very small denticled pieces. Mandibles wing-shaped, each with a spine. Setae all of one kind, limbate, smooth, tapering to long flexible tips. Prostomium with four eyes in transverse row. (Up to 70 segments.) Parasitic in body cavity of syllids, *Odontosyllis ctenostoma, Syllis prolifera, Eusyllis monilicornis, Pionosyllis lamelligera, Grubea clavata.* Also found free among calcareous algae, *Lithothamnion.*
Genus *Labrorostratus* Saint-Joseph *L. parasiticus* Saint-Joseph



E² Maxillae three pairs recurved unidentate hooks. Mandibles U-shaped, with two wing-like pieces or rods united by transverse band. . . . Genus *Oligognathus* Spengel

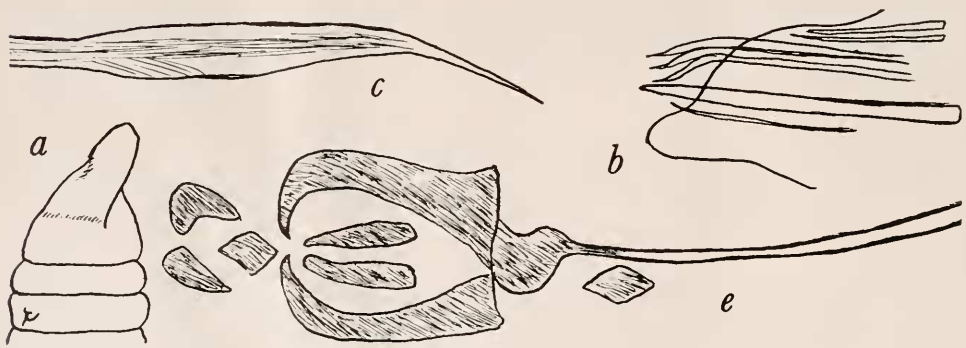
F¹. Setae of one kind, simple, arched, limbate, striated. Prostomium with four eyes. (Up to 100 mm. long, more than 200 segments. Bright orange yellow.) Parasitic in body cavity of echiuroid, *Bonellia viridis*.
O. bonelliae Spengel

F². Setae of two kinds: capillary, flexible and stouter, wide, tapering to fine tips. Prostomium without eyes. (Up to 8 mm. long. 50 segments. Colorless, transparent.) Parasitic in body cavity of spionid, *Spio mecznikowianus*.
O. parasiticus Cerruti



C². Four pairs of well developed maxillae, with pair of elongate rodlike maxillary carriers and shorter unpaired piece (basal or maxillae I large, strong, hooked, forceps-like; maxillae II rectangular plates, sometimes denticled; maxillae III and IV each a single strong thorn-like tooth). Mandibles absent. Parapodia with heavy acicula or acicular setae, the tips of which usually protrude. Prostomium without eyes.
Genus *Drilonereis* Claparède (includes *Labidognathus* Caullery; see below).

G¹. Parasitic in peri-intestinal blood sinus of terebellid (unidentified). With bilimbate setae and single stout acicular seta extending out of parapodial lobe. Maxillae II edentate (?, incompletely observed). (More than 100 segments). . . . *D. parasiticus* (Caullery)



G². Parasitic in body cavity of branchial fragment of eunicid, *Eunice* sp., possibly *E. antennata*. With bilimbate setae and single stout yellow aciculum, the latter not extending out of parapodial lobe. Maxillae II flat plates, practically without teeth. (More than 140 segments, more than 30 mm. long.). . . . *D. forcipes* (Hartman)

G³. Parasitic in body cavity of onuphids. Maxillae II rectangular plates, each with four distinct teeth.

H¹. Parasitic in branchial fragment of *Onuphis magna*. Without setae or acicular setae visible externally (even in a specimen of more than 1200 crowded segments and more than 240 mm. long). . . . *D. benedicti* n. sp. See Fig. 1, a-g.

H². Parasitic in anterior fragment of *Onuphis* (*Nothria*) *conchylega*. With limbate setae and single stout acicular seta extending from lobe (except in smaller specimens; up to 400 segments, 110 mm. long). . . . *D. caulleryi* n. sp. See Fig. 2, a-o.

The parasitic arabellids may be separated into two main groups. The first includes those species of which numerous specimens are found in a single host. Within a single host, they may be found in varying stages of development, from small specimens, with few segments, no eyes, and no jaws, to larger ones, with numerous segments, eyes, developing jaws, parapodia, and setae. The two reported cases are thought to be the young stages of species of *Notocirrus*. When first observed by Koch (1847), they were reported as a lumbrinerid-like stage of the young of the presumably viviparous eunicid host, *Marphysa sanguinea;* this species lives in a loose mucous tube, irregularly encrusted with rocks, shells, and such. Similar forms have since been found in the onuphid, *Diopatra cuprea,* which lives in a parchment-like tube, one end of which is buried in the sand or mud, the other end sticking out of the substratum and covered with shells, plant debris, etc. The parasites evidently penetrate the host at an early stage, just how early and the mechanism for penetration being unknown. They grow and develop within the host to an advanced stage, when they evidently leave the host and perhaps continue to grow and mature, taking on a free-living existence.

The other type of parasitism is the condition where a single parasite is found in a host and where the parasite may attain enormous dimensions in comparison to the host, becoming nearly as large or larger than the host or host fragment. They evidently penetrate the host at an early stage also and grow to an advanced stage, perhaps even completing their growth within the host. The parasite may be completely enclosed in the host or part of it may protrude. Perhaps it matures after leaving the host, as sex products have not been observed in the parasites found in the host.

The parasitic arabellids appear to be rare. Most of the records of the different species have been based on single specimens. In a long study from 1875 to 1888 at Dinard, Saint-Joseph (1888) observed only 14 examples of *Labrorostratus parasiticus* in the body cavities of several species of syllids. After numerous years of microscopical examination of numerous syllids, Caullery and Mesnil (1916) observed only a single parasite of the same species. Considering that the syllids are small and somewhat transparent and that the parasites may be as much as three-fourths of the length of the host, the presence of the parasites would probably be

noted. Where the host is larger and opaque, the parasites would be observed only accidentally in fragmented or dissected specimens.

Four of the parasitic species belong to the genus *Drilonereis,* which also includes free-living species. The maxillae and maxillary carriers are well developed. In *D. caulleryi* n. sp. the parapodial armature develops gradually; first the heavy aciculum appears, then the setae, only the tips of which project at first, then the setae project further and the tips of the heavy acicula finally protrude. In *D. benedicti* n. sp. the acicula and setae are rudimentary and do not project from the parapodial lobes, even in a specimen of more than 1200 crowded segments. The parasitic genera, *Oligognathus* Spengel, *Labrorostratus* Saint-Joseph, and *Haematocleptes* Wirén, have the maxillae more rudimentary than in *Drilonereis,* with a single elongate rodlike maxillary carrier, darker toward the outside. *Haematocleptes terebellidis* shows the most rudimentary condition, having only a single pair of maxillae and the setae and acicula not projecting from the parapodial lobe.

Genus *Drilonereis* Claparède, 1870

Type (by original designation) : *D. filum* (Claparède, 1868).
Labidognathus Caullery 1914; type (by monotypy) : *L. parasiticus* Caullery, 1914.

Diagnosis. Prostomium conical to spatulate, flattened ventrally, usually with central depression dorsally, without eyes or appendages. First two segments apodous and achaetous, first sometimes partially fused dorsally to prostomium. Parapodia with dorsal lobe or notopodium usually small, rudimentary, with a few embedded notopodial acicula; neuropodium with two unequal lips, supported by acicula. Setae all simple, of two kinds: (1) bilimbate or winged, tapering to fine tips, smooth or faintly striated (not denticled); (2) 1–2 stout acicular setae with tips protruding from parapodial lobe; (in some parasitic forms, setae may be rudimentary, not extending out of parapodial lobes). Pharynx with mandibles or lower jaws rudimentary or absent; maxillae or upper jaws 4–5 pairs, symmetrical, dark, chitinous, supported by a pair of long slender maxillary carriers and a shorter unpaired piece; basal maxillae I large, heavy, falcate pincers or forceps; maxillae II rectangular plates, usually denticled; maxillae III and IV with one to few teeth; maxillae V rudimentary or absent.

Remarks. Labidognathus is herein referred to *Drilonereis.* The type species of the former, *L. parasiticus* Caullery (1914, p. 490), was found living as a parasite in a terebellid (not yet described) near Timor, Dutch East Indies; the parasite was found in the peri-intestinal blood sinus, coiled in a complicated manner around the intestine of the host. According to Caullery, both the host and parasite were in rather poor condition; the jaw apparatus of the parasite was not studied completely. Hartman (1944, p. 180) noted the affinities of *Labidognathus* with *Drilonereis* and described a new species, *L. forcipes,* found in the body cavity of a fragment of a species of *Eunice* from San Benito Island, Mexico. In addition two new species are described below. Because of the scarcity of material of the parasites, it is difficult to work out the developmental stages. As indicated below for the four specimens of *Drilonereis caulleryi* n. sp., parasitic in *Onuphis conchylega,* there are differences in the development of the jaws and parapodia in different stages of growth. The four parasitic species of *Drilonereis* show essentially the characters

of the genus. They all lack mandibles and have four pairs of maxillae, of which maxillae I are stout falcate hooks and maxillae III and IV each a single stout conical hook. The parasites were found singly, one to a host. The hosts, at least when collected, were either anterior or middle fragments, with the parasites protruding and exposed in part.

Drilonereis benedicti n. sp.

Fig. 1, A–G

The species is known from a single specimen, incomplete posteriorly (U.S.N.M. No. 28637), found in a fragment of 18 segments from the branchial region of

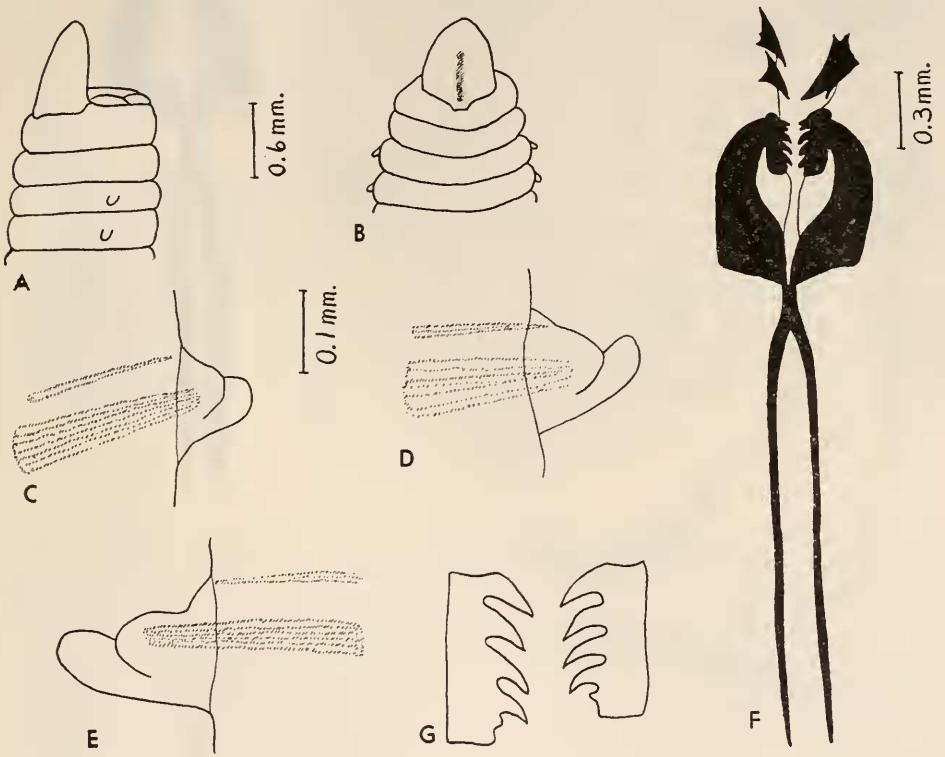


FIGURE 1. *Drilonereis benedicti* n. sp.: A, Lateral view anterior end; B, dorsal view anterior end; C, left parapodium from setiger 10, anterior view; D, same from about setiger 300; E, right parapodium from about setiger 600, anterior view; F, four pairs maxillae and maxillary carriers, dorsal view (more ventral unpaired piece not shown); G, maxillae II, enlarged.

Onuphis magna (Andrews), North Channel into Tampa Bay, Florida, 12 fms., *Fish Hawk* Sta. 7108, 1901, Dr. J. E. Benedict, collector. The parapodia of the host fragment were compared with those of an incomplete specimen of *O. magna* found at the same station. The middle part of the parasitic *Drilonereis* extended through the body cavity of the host fragment, the greater part of the anterior and posterior

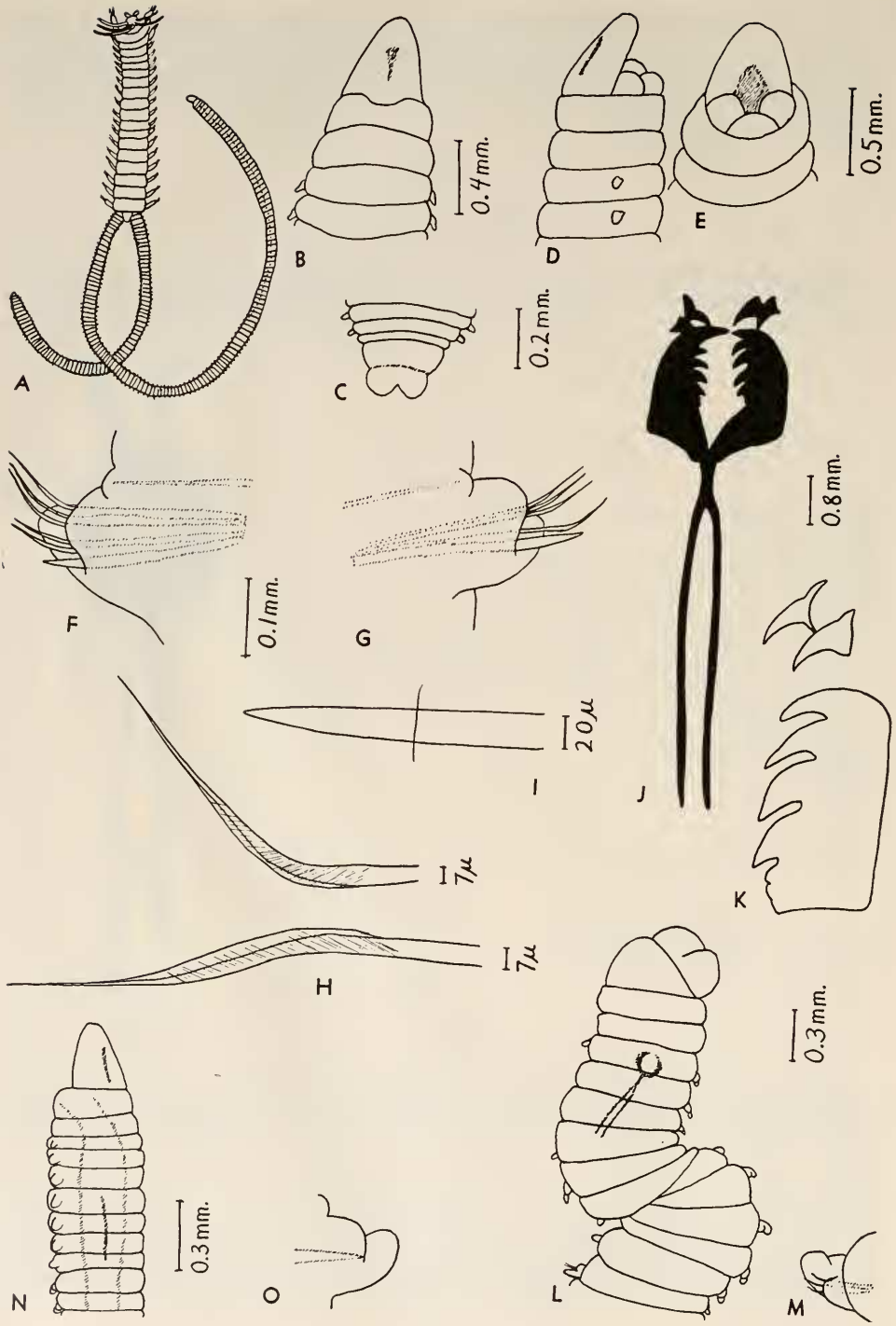

A
B
0.4mm.
C
0.2mm.
D
E
0.5mm.
F
0.1mm.
G
0.8mm.
I
20μ
J
K
17μ
H
17μ
0.3mm.
N
0.3mm.
O
L
M

FIGURE 2.

ends of the parasite being exposed. It is named for the collector, who evidently put it aside to be worked up later.

Description. Length of incomplete specimen 240 mm., greatest width 1.5 mm., segments more than 1200. Body cylindrical, with segments slightly longer anteriorly becoming very short and crowded posteriorly, colorless (in alcohol), shiny iridescent anteriorly, dull posteriorly. Prostomium (Fig. 1, A, B) conical, rounded anteriorly, flattened ventrally, with a longitudinally depressed area mid-dorsally. First two segments achaetous, subequal to the following, first with mid-dorsal nuchal notch. Parapodia (Fig. 1, C–E) similar along length of body, small, unequally bilobed, with shorter rounded and longer thick digitiform lobes. No setae exposed external to lobes; internally few notopodial acicula extending into base of rudimentary low notopodial lobe and larger group of neuropodial acicula and setae with tips extending into the short neuropodial lobe; one of the acicular group is much stouter, probably corresponding to the stout acicular seta characteristic of *Drilonereis*. Proboscis without mandibles and with four pairs maxillae. Maxillae (Fig. 1, F, G) well developed, dark, with a pair of long, dark filiform maxillary carriers and short oval unpaired piece, dark anteriorly, light amber-colored posteriorly; basal maxillae I stout, falcate, hooked; maxillae II rectangular plates, each with four distinct teeth and slight indication of a fifth; maxillae III and IV each a single, large, thorn-like tooth.

Remarks. D. benedicti differs from the other parasitic species of *Drilonereis* in the complete absence of exposed setae, even in a specimen of more than 1200 segments. The host normally lives in a parchment-like tube. Perhaps the host fragment moves along in the tube carrying the parasite with it. Possibly the parasite at this stage feeds for itself, as the anterior and posterior ends were exposed. There is also the possibility that the host fragmented at the time it was collected.

Drilonereis caulleryi n. sp.

Fig. 2, A–O

The species is represented by four specimens, each of which was found living parasitically in anterior fragments of *Onuphis* (*Nothria*) *conchylega* Sars, collected by the *Fish Hawk* and *Albatross* off Martha's Vineyard, Massachusetts, and off Cape Henry, Virginia, from 1880 to 1883. Two of the four specimens are small, showing different developmental stages. The specimen designated as the type (U.S.N.M. No. 12867) is complete and was found coiled inside a host of about 40 anterior segments. The largest paratype (U.S.N.M. No. 8987) consists of an anterior end of 25 mm. and a posterior end of 10 mm. protruding from the posterior

FIGURE 2. *Drilonereis caulleryi* n. sp.: A, Habit sketch of parasite and host (2); B, dorsal view anterior end (1); C, dorsal view posterior end (1); D, lateral view anterior end, proboscis partially extended (2); E, ventral view same; F, left parapodium from setiger 20, anterior view (1); G, right parapodium from middle of body, anterior view (1); H, limbate setae from same; I, acicular seta from same; J, four pairs maxillae and maxillary carriers, dorsal view (more ventral unpaired piece not shown) (2); K, right maxillae II–IV, enlarged; L, dorsal view anterior end of slightly coiled smaller paratype, proboscis partially extended (3); M, parapodium from setiger 10 of same; N, slightly lateral view anterior end of smallest paratype (4); O, parapodium from setiger 12 of same. (1) type specimen; (2) largest paratype specimen; (3) smaller paratype specimen; (4) smallest paratype specimen.

end of the host fragment of 18 segments, the middle part of the parasite being inside the host (Fig. 2, A). A smaller paratype (U.S.N.M. No. 28636) occupied setigers 8–18 of an anterior fragment of a host of 18 segments; the posterior end of the parasite protruded from the posterior end of the host fragment. A very small paratype (U.S.N.M. No. 28635) was found in a host fragment of 17 segments; the anterior end of the parasite was sticking out dorsally between setigers 15 and 16, the posterior end was protruding ventrally between the same segments. The species is named for Dr. Maurice Caullery, who described the first parasitic drilonereid (as *Labidognathus*).

Description. Length up to 110 mm., greatest width up to 1 mm., segments up to 400 or more. Body cylindrical, shiny iridescent. Prostomium (Fig. 2, B, D, E) conical, rounded anteriorly, flattened ventrally, with a mid-dorsal depressed area. First two segments apodous and achaetous, subequal to the following, first with mid-dorsal nuchal notch. Anal end (Fig. 2, C) short, cylindrical, tapering to pair of short bulbous lobes (no distinct anal cirri). Parapodia (Fig. 2, F, G) similar along length of body, short, unequally bilobed, with shorter rounded and longer, thick digitiform lobes. Two larger specimens with two kinds of setae projecting from parapodial lobe: 4–5 bilimbate, straight and curved setae, tapering to slender tips, faintly striated (not denticled; Fig. 2, H); also single yellowish stout, pointed acicular seta (Fig. 2, I); with additional internal neuropodial acicula as well as few notopodial acicula, the tips of which extend into short bulbous rudimentary notopodium; posterior end of body with tips of limbate setae only projecting from parapodial lobes. Smaller specimen (12+ mm. long, 0.6 mm. wide) with tips of limbate setae only extending out of lobe, stout acicular seta being visible inside lobe (Fig. 2, 1, M). Smallest specimen (5 + mm. long, 0.3 mm. wide) with no setae projecting, single stout acicular seta being visible inside parapodial lobe (Fig. 2, N, O). Proboscis, when partially extended, appearing as three bulbous lobes (Fig. 3, D, E); no mandibles; maxillae four pairs, well developed, dark, with pair of long filiform carriers and shorter wide oval unpaired piece, dark anteriorly, lighter more posteriorly (Fig. 2, J, K); maxillae I stout, falcate, forceps-like; maxillae II rectangular plates, each with four distinct teeth; maxillae III and IV each a single large hooked thorn-like tooth. In smaller specimen, maxillary forceps and slender carriers visible through transparent body wall (Fig. 2, L). In smallest specimen (Fig. 2, N) only maxillary carriers visible.

Remarks. D. caulleryi differs from the other parasitic species of *Drilonereis* as indicated in the key above. As shown in the three developmental stages found in the four specimens, the maxillary carriers develop first, then the stout maxillary forceps; in the parapodia, the stout acicular seta appears first, then the limbate setae, the tips of which may protrude, the stout acicular seta not protruding (this would correspond to the condition described for *D. forcipes* by Hartman); finally the limbate setae protrude further and the tips of the stout acicular setae protrude. The host, *Onuphis conchylega* Sars, occupies a flat parchment-like tube encrusted with flattened pieces of rocks and shells. All four host specimens are anterior fragments. The parasite may be completely enclosed in the host fragment or a portion of the parasite may stick out, revealing its presence. The parasite perhaps gets into the host by encouraging it to fragment; none of the fragments showed any signs of regeneration, although *O. conchylega* fragments and regenerates readily.

Material examined. Type: off Martha's Vineyard, Massachusetts, 39° 53′ N., 69° 47′ W., 317 fms., soft green mud, *Fish Hawk* Sta. 1096, 1882. Paratypes: 40° 02′ N., 70° 23′ W., 115 fms., mud, fine sand, *Fish Hawk* Sta. 871, 1880; 40° 02′ N., 70° 37′ W., 101 fms., grey mud, fine sand, *Fish Hawk* Sta. 1108, 1882; off Cape Henry, Virginia, 37° 19′ N., 74° 26′ W., 102 fms., green mud, shell, *Albatross* Sta. 2004, 1883.

Distribution. Atlantic, off Massachusetts to off Virginia. 101 to 317 fathoms.

Genus *Notocirrus* Schmarda, 1861, emend. Ehlers, 1868

Type (designated by Ehlers, 1868, p. 406) : *N. chilensis* Schmarda, 1861.

Diagnosis. Prostomium conical, without appendages, usually with 4 eyespots. First two segments apodous and achaetous. Parapodia with dorsal lobe or notopodium represented by small rudimentary lobe and few notopodial acicula; neuropodium unequally bilobed, supported by stout acicula, the tips of which project (except in young developing stages). Setae all simple, bilimbate or winged, tapering to fine tips, striated and finely to coarsely denticled along limbate border. Pharynx with pair of wing-shaped, dark chitinous mandibles or lower jaws; maxillae or upper jaws 4–5 pairs, dark, chitinous, denticled, supported by pair of long filiform maxillary carriers and shorter unpaired piece; maxillae I and II asymmetrical, maxillae I dentate throughout entire length or only slightly falcate or with short hook distally.

Remarks. Notocirrus has affinities with *Arabella,* having similar prostomia and pharyngeal jaws; both have limbate setae with denticled border. *Notocirrus* also has affinities with *Drilonereis,* both having stout acicula or acicular setae which project from the parapodial lobes. A species of *Notocirrus* is herein reported to be parasitic in an onuphid (*Diopatra*) during its early development.

Notocirrus spiniferus (Moore, 1906)

Figs. 3–5

Arabella spinifera Moore, 1906, p. 501, pl. 19, figs. 1–7.

The species was described from a single specimen which was dredged on muddy bottom in the middle of Buzzards Bay, Massachusetts. No additional records have been reported. In working over a good deal of material collected in New England and vicinity, four additional free-living specimens were found. The species appears to be rare but, due to its superficial resemblance to the more common *Arabella iricolor,* it may be confused with that species in collections. The four specimens were obtained from the following sources: Buzzards Bay, Massachusetts, 1956, H. Sanders, collector; off Cape Henry, Virginia, Chesapeake Bay, 9 fms., shelly and sand, *Fish Hawk* Sta. 8838, 1920; Isle of Wight Bay above Ocean City, Maryland, 1953, S. McDowell, collector; Beaufort, North Carolina, 1951, E. Cole, collector.

In addition two of the specimens found living parasitically in the body cavity of *Diopatra cuprea* (Bosc), collected by M. Jean Allen at Hadley Harbor, Nonamesset Island, Woods Hole region, Massachusetts, were examined. They ap-

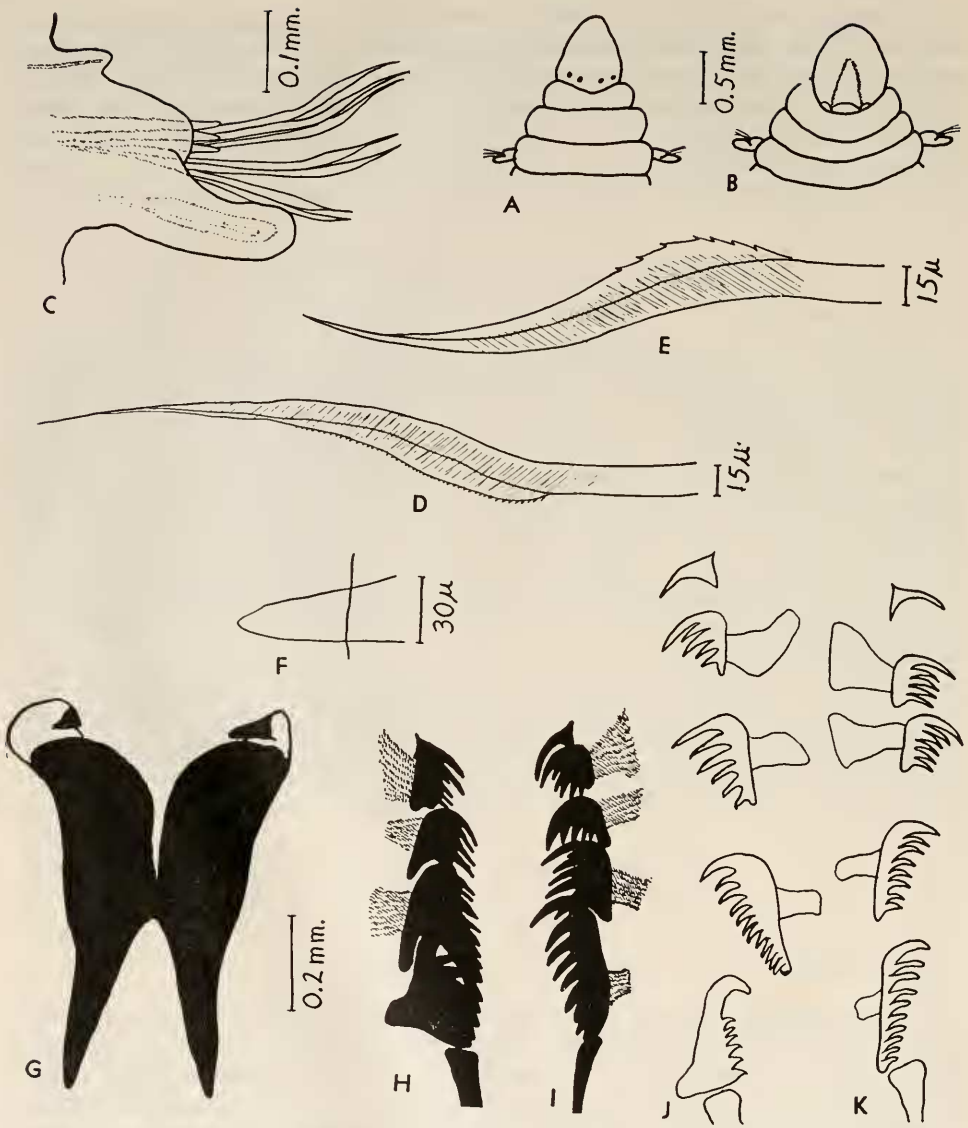


FIGURE 3. *Notocirrus spiniferus.* Drawn from specimen from Buzzards Bay: A, Dorsal view anterior end; B, same, ventral view; C, parapodium from setiger 10, posterior view; D, limbate seta from same; E, limbate seta from setiger 100; F, tip of one of acicula from same; G, mandibles, ventral view; H, left maxillae, I–IV, dorsal view; I, right maxillae, I–IV, dorsal view; J, left maxillae spread apart; K, right maxillae spread apart.

pear to be the young of a *Notocirrus*, possibly that of *N. spiniferus*. In a note recording the find of more than 50 parasitic specimens in a single specimen of *Diopatra*, Allen (1952) indicated that they might be the young of *Arabella iricolor* but the parapodia differ from that species as indicated below.

Description of specimens found free-living. Length 40–110+ mm., width 1–4 mm., segments 140–220+. Body cylindrical, tapering slightly anteriorly and posteriorly, stiff, wiry. Prostomium (Figs. 3, A, B; 4, A, B) subconical, rounded anteriorly, slightly depressed dorsoventrally but not greatly flattened as in *Drilonereis;* a pair of faint longitudinal grooves ventrally and four eyes in transverse row at posterodorsal border, rather than two eyes as reported by Moore. First two segments achaetous and apodous, first with mid-dorsal nuchal notch. Parapodia (Figs. 3, C; 4, D) prominent, similar along length of body, with small but distinct notopodium supported internally by few notoacicula; neuropodium bilobed, with

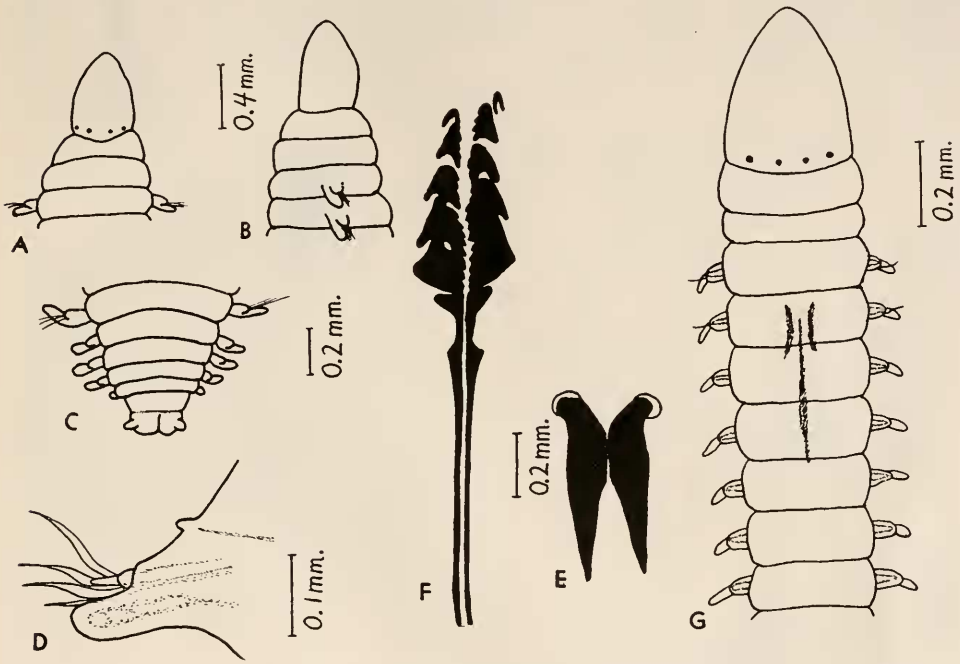


FIGURE 4. *Notocirrus spiniferus.* Drawn from specimen from Isle of Wight Bay (A–F): A, Dorsal view anterior end; B, lateral view same; C, dorsal view posterior end; D, parapodium from middle of body; E, mandibles, ventral view; F, five pairs maxillae and maxillary carriers, dorsal view (more ventral unpaired piece not shown). G, Dorsal view anterior end of small specimen of *Notocirrus ?spiniferus,* living parasitically in *Diopatra cuprea,* Woods Hole region.

short rounded setal lobe and longer, prominent digitiform postsetal lobe (sometimes referred to as ventral cirrus or cirriform branchial organ), within which is a vascular loop. Setal lobe with 1–3, usually 2, stout, deep yellow acicula, the tips of which project out of lobe (thus differing from *Arabella,* which has no stout projecting acicula); acicular tips bluntly pointed, tapered abruptly to short fine tips, or sometimes obviously broken (Fig. 3, F). Setal lobe with 4–8 bilimbate, doubly curved setae with fine tips, with wings wide, striated and finely denticled along border, sometimes with a few coarser denticles near base of wing (Fig. 3, D, E). Anal end (Fig. 4, C) tapered to pair of short bulbous lobes, each with very short rudimentary anal cirrus.

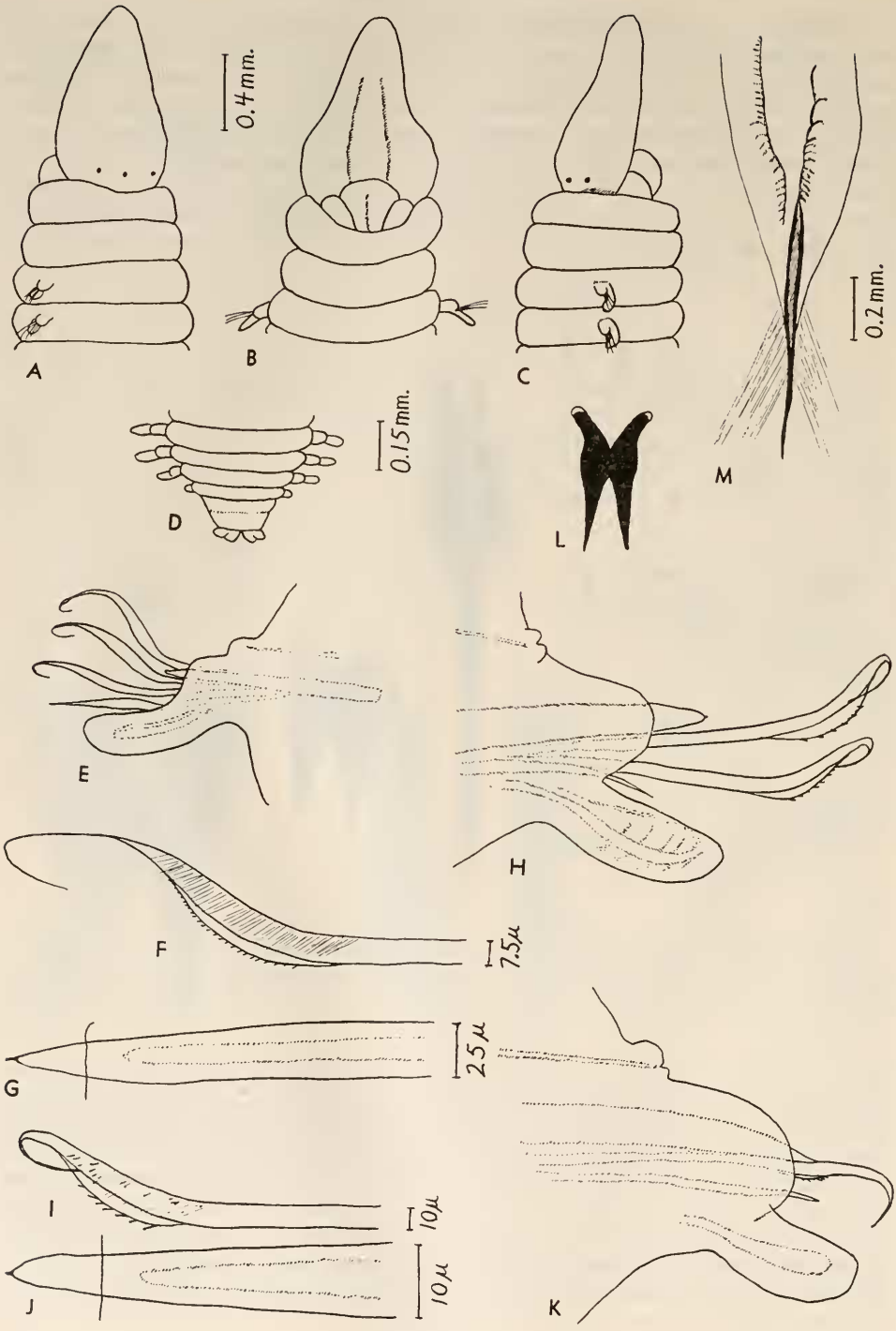


FIGURE 5.

Proboscis, when partially extended, appears as bulbous bilobed tongue with pair of lateral lobes. Ventral mandibles (Figs. 3, G; 4, E) well developed, brown or black, wing-shaped, sometimes with exposed white tips. Five pairs of dorsal jaws or maxillae (Figs. 3, H–K; 4, F), with pair of long slender carriers, thickened distally and subdistally, and shorter unpaired piece; fifth pair, consisting of single tooth, easily confused with the fourth, to which it is closely allied. First two or basal pairs of maxillae asymmetrical. Right maxilla I longer than left, with up to 10 denticles along length of inner border and without distal hook; left maxilla I with up to six basal teeth and distinct distal hook. (Moore, in figure of the type, showed distal hooks on both first maxillae and fewer teeth.) Left maxilla II much larger than right, completely overlapping left maxilla I and extending down to maxillary carriers, with up to 12 or 13 teeth; right maxilla II partially overlapping right maxilla I, with up to 8 or 10 teeth. Maxillae III to V symmetrical, III each with 6 teeth, IV each with 5 teeth, and V each a single tooth, without basal extension as in other maxillae. (The last may appear to blend in with maxillae IV and this may have led to Moore's count of only four pairs of maxillae.) Color (in alcohol) yellowish to brownish, iridescent.

Description of two young specimens of Notocirrus ?spiniferus, living parasitically in Diopatra cuprea. The larger parasitic specimen is 25 mm. long, 1.5 mm. wide, and consists of almost 200 segments. The smaller specimen is 12 mm. long, 0.5 mm. wide, and contains about 150 segments. Prostomium of smaller one (Fig. 4, G) conical, bullet-shaped, that of larger one (Fig. 5, A–C) more elongated, bulbous basally; both show four eyes in transverse row. Parapodia of smaller specimen showing characteristic bilobed form, without setae projecting except for first two setigerous segments in which a single seta projects; each of setal lobes provided with stout aciculum (appears dark basally). In larger specimen, parapodia of anterior region (Fig. 5, E) with four limbate setae and single stout aciculum; those of middle region (Fig. 5, H) with two limbate setae and tip only of a third one projecting; those of posterior region (Fig. 5, K) with single limbate seta and tip of a second one projecting; notopodia small but distinct, with tip of notaciculum extending into lobe. Limbate setae with long fine tip, curled backward, distinctly denticled along limbate border (Fig. 5, F, I); stout projecting acicula with fine short tips (Fig. 5, G, J). Thus parapodia essentially as in larger free-living specimens of *Notocirrus spiniferus* except for fewer acicula and setae. Anal end of small specimen tapering gradually to cylindrical posterior end, without distinct anal cirri; that of larger specimen (Fig. 5, D) essentially as in *N. spiniferus*. Pharynx, when partially extended, appears as three-lobed structure, the middle lobe rounded, tongue-like, consisting of pair of lobes (Fig. 5, B). Jaw parts of smaller specimen (Fig. 4, G) not dissected but darker paired mandibles and maxillary carriers visible through the somewhat transparent body wall, maxillary carriers appearing as single elongated rod. Jaw parts of larger specimen, when dissected out, showing well

FIGURE 5. Young *Notocirrus ?spiniferus*, parasite taken from body cavity of *Diopatra cuprea*, Woods Hole region: A, Laterodorsal view anterior end; B, ventral view same; C, lateral view same; D, dorsal view posterior end; E, parapodium from setiger 10; F, limbate seta from same; G, aciculum with projecting tip from same; H, parapodium from middle of body; I, limbate seta from same; J, aciculum with projecting tip from same; K, parapodium from posterior part of body; L, mandibles, ventral view; M, developing maxillary carriers and maxillae, dorsal view.

developed mandibles (Fig. 5, L), and incompletely developed maxillae (Fig. 5, M) with elongated rodlike maxillary carriers (appearing as single rod but darker toward the outside), and developing denticled maxillae, indicated by slightly darker amber-colored areas on walls of pharynx.

Remarks. The smallest parasites reported by Allen were composed of seven segments; some specimens of 30 segments showed no eyes or setae; the largest specimen reported was 50 mm. long and was composed of about 200 segments. These parasites had not emerged naturally from the host. Thus they live a parasitic life for a considerable period. The smaller specimens were in the body wall of the host near the parietal blood vessels, the larger ones were free in the body cavity. A few large parasites were observed emerging from the body cavity of *Diopatra* by Dr. Frank Brown (Allen, 1952), but the lengths and the developmental stages of these specimens were not indicated. It may be that the parasites remain in *Diopatra* until the jaw parts are completely developed; they were not completely developed in the largest specimen I was able to examine. It is unknown how the parasites get into the host. Perhaps the eggs of *Notocirrus* are laid and fertilized within the tube of *Diopatra*. *Notocirrus,* being a burrowing form, could enter the parchment-like tube of *Diopatra* on the buried end which, as far as has been observed, is open. In some way, the fertilized eggs or young at a very early stage get into the body cavity of *Diopatra.* The posterior end of *Diopatra* is soft and flaccid and fragments easily; perhaps the young are able to bore into the broken fragmented end of the host. *Diopatra* regenerates readily also. One host, found by Allen, contained about 30 small parasites, composed of from 7 to approximately 30 segments; another host contained over 50 parasites of varying sizes, some up to 50 mm. in length.

In this connection, it may be of interest to mention the observation made by Koch (1847) of filamentous lumbrinerid-like forms crawling out of a broken truncated posterior end of a strongly contracting specimen of *Marphysa sanguinea,* which was dredged at considerable depth in the Mediterranean. On further examination of the *Marphysa,* he found numerous young specimens in the body cavity, in various stages of development; the smallest were small roundish microscopic forms with only slight indication of a few segments and without eyes; a more advanced stage of 25–30 segments showed a distinct prostomium with 2 eyes, parapodia with stout aciculum only, and jaw apparatus in early stages of development; a still more advanced stage of 50–100 segments showed a distinct prostomium with 4 eyes in a transverse line, parapodia with 2 stout acicula and a few setae confined to the parapodia; a still later stage of 100–120 segments showed the parapodia with a short rounded setal lobe and a longer postsetal lobe, with stout dark yellow acicula, the tips of which appear from Koch's figure to project, as in *Notocirrus* or *Drilonereis,* and the jaw apparatus well formed (probably not completely formed). Koch thought that the specimens he observed were the young stages of a viviparous *Marphysa sanguinea* and that during its development, the young pass through a lumbrinerid-like stage. Ehlers (1868, p. 364), commenting on the observation of Koch, indicated that Koch had more likely observed parasitic forms of a lumbrinerid-like species living in *M. sanguinea* and that the latter was not viviparous; he stated that it was unreasonable to think that a young specimen of *M. sanguinea* of more than 100 segments would not show some of the characteristics of the adult, that of antennae, branchiae, characteristic setae, etc. In consideration

of the long jaw pieces (maxillary carriers) and the four eyes, Ehlers concluded that it might be a parasitic species of *Arabella*. The figures and description given by Koch suggest to me that the young developing stages in *Marphysa* that he observed, were the parasitic young stages of a species of *Notocirrus*, as indicated especially by the long maxillary carriers, the stout parapodial acicula, and the four eyes in a transverse row.

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